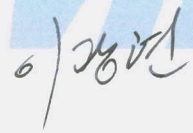
Quality Management Plan (QMP) and Quality Assurance Project Plan (QAPP) for Shipboard Testing of BWMS (AquaStar™ BWMS)

Project ID: AquaStar Shipboard

Korea Marine Equipment Research Institute
1125-22 Dongsam-dong, Youngdo-gu, Busan, Republic of Korea

Quality Statement

Full Title of the quality assurance document:	Quality Management Plan (QMP) and Quality Assurance Project Plan (QAPP) for Shipboard Testing of BWMS (AquaStar™ BWMS)
Project ID:	AquaStar Shipboard
Organizations to which the quality assurance document applies:	1) AQUA Eng. Co., Ltd., Busan, Republic of Korea 2) Korea Marine Equipment Research Institute (KOMERI), Busan, Republic of Korea
Effective date of the quality assurance document:	17 February 2011 to 31 December 2011
Applicant (BWMS developer) :	Gwang-Hyun Lee
Position:	Executive Director
Signature:	
Date:	17 February 2011
Project Director (KOMERI):	Young-Soo Kim
Position:	Team Manager
Signature:	
Date:	17 February 2011

Approval Sheet

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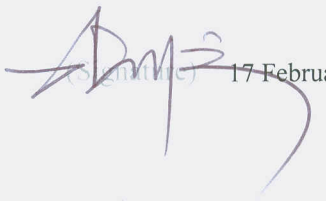
Position: Team manager
Organization: KOMERI


17 February 2011

Quality Assurance Manager
Name: Jae-Uk Kang
Position: Team manager
Organization: KOMERI


17 February 2011

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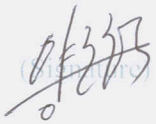
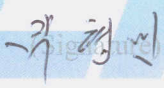

17 February 2011

Statistical Personnel
Name: Jun-Hak Lee
Position: Researcher
Organization: KOMERI


17 February 2011

Archive Personnel
Name: Hyung Min Park
Position: Researcher
Organization: KOMERI


17 February 2011

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Introduction & Background

AQUA Eng. Co., Ltd. is seeking the Type Approval from the Korean Administration for its proprietary AquaStar^{TM} ballast water management system (BWMS). This approval is being sought in accordance with the *Guidelines for Approval of Ballast Water Management Systems* (G8) as adopted by Res. MEPC 174(58) (2008) of the International Maritime Organization (IMO) and The Provisional Regulation for Type Approval of Ballast Water Management System (PR. No. 2011-342) by the Ministry of Land, Transport and Maritime Affairs, respectively.

Part 2, Section 2.1.2 of the G8 requires that the testing process for BWMS should include both a Quality Management Plan (QMP) and a Quality Assurance Project Plan (QAPP). The QMP addresses the overall quality management policies and structures of the testing body, and the QAPP provides the detailed quality assurance arrangements for the actual testing procedures.

Accordingly, Korea Marine Equipment Research Institute (KOMERI) – a Type Approval Test Organization approved by the Ministry of Land, Transport and Maritime Affairs, Korea – has developed its QMP and QAPP for approvals of BWMS.

As the G8 does not provide any guideline as to the structure, format and content of the required QMP and QAPP (except referring to generic international standards), and as such guideline is not available from IMO, KOMERI has adopted the following as the standard for the QMP and QAPP:

- US EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5)
- US EPA Guidance for Quality Assurance Project Plans (EPA QA/G-5)
- KOMERI KOLAS Manual, Procedure and direction documents, 2010

Quality Management Plan (QMP)

1. GENERAL

All laboratories at Korean Marine Equipment Research Institute (KOMERI) comply with the Korean Laboratory Accreditation Scheme (KOLAS – www.kolas.go.kr) system for laboratory and research organizations as outlined in Korean national regulations, to ensure the consistency and reliability of laboratory testing results.

All testing and analysis procedures and equipments at KOMERI are certified by the KOLAS to KS ISO/IEC 17025 standard. The certification number for KOMERI is KT-190 and a copy of the current KOLAS accreditation is attached.

The KOLAS accreditation of KOMERI provides the overall QMP (ISO/IEC 17025) and QAPP for all of its testing activities relating to the shipboard testing.

Scope of Certificate for Quality Management System of KOMERI is as follows:

(1) Field sampling
(2) Sample transit
(3) Sample preservation
(4) Laboratory and Field analysis
(5) Measurement and Data acquisition

No. 190 (1/33)

CERTIFICATE OF ACCREDITATION

Name of Laboratory : KOREA MARINE EQUIPMENT RESEARCH INSTITUTE

Representative : Kim, Gi-Jung

Address of Headquarters : 1125-22, Dongsam-dong, Youngdo-gu, Busan 606-806, Korea

Address of Laboratory : 1631-10, Songjeong-dong, Gangseo-gu, Busan 618-270, Korea

Duration : Jan. 29, 2008 ~ Jan. 28, 2012

Scope of Accreditation
(Scope of Accreditation is described in the accompanying Annex)

This testing laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025 : 2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated 8 January 2009).

March. 24 , 2010

Huh. Kyung

Administrator,
Korea Laboratory Accreditation Scheme(KOLAS)

9. Biological Test

9.006 Aquatic biology

규격번호	규 격 명
APHA 9215:2005	American Public Health Association (APHA) / Heterotrophic plate count
APHA 10200 C:2005	American Public Health Association (APHA) / Concentration techniques
EPA 445.0:1997	U.S. Environmental Protection Agency (EPA) / In vitro determination of chlorophyll-a and pheophytin-a in marine and freshwater algae by fluorescence
EPA 1600:2006	U.S. Environmental Protection Agency (EPA) / Enterococci in water by membrane filtration using membrane-Entrococcus indoxyl-β-D-glucoside agar (mEI)
EPA 1603:2006	U.S. Environmental Protection Agency (EPA) / Escherichia coli (E. coli) in water by membrane filtration using modified membrane-thermotolerant Escherichia coli agar(Modified mTEC)
UNESCO 4:2003	United Nations Educational, Scientific and Cultural Organization (UNESCO) / Estimating cell numbers
APHA 2540 D:2005	Total Suspended Solids Dried at 103-105oC
APHA 9222 B:2005	Standard Total Coliform Membrane Filter Procedure
ISO 15705:2002	Water quality-Determination of the chemical oxygen demand index (ST-COD)-Small-scale sealed-tube method
APHA 5210 D:2005	Respirometric method

End.

2. RESPONSBILITY

The measurement items and the quality system of this shipboard testing are summarized in Table 1. The overall distribution of responsibilities in the test team is shown in Figure 1 and Table 2.

Table 1. Measurement items and quality system

Organization	Measurement items	Quality system
KOMERI	**Efficacy testing** - Organism viability (≥ 50 μm) - Organism viability (≥ 10 - 50 μm) - *Escherichia coli*/Coliform - Intestinal Enterococci - Heterotrophic bacteria - Toxicogenic *V. cholera*e (O1, O139)	- ISO/IEC 17025 - Type Approval test organization by Korean government (Ministry of Land, Transport and Maritime affairs)

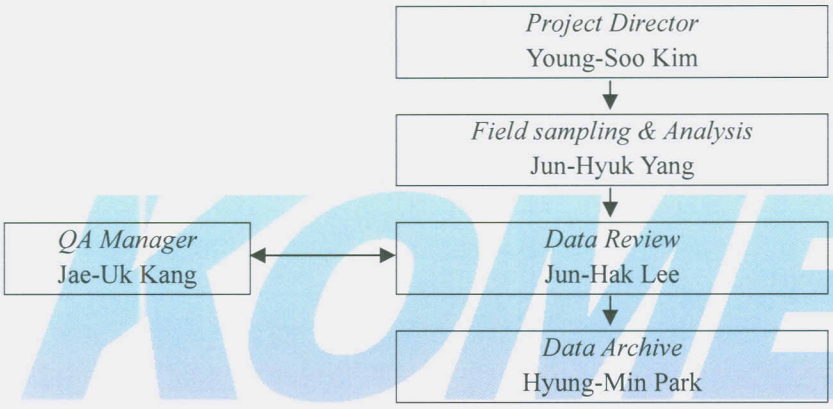

Figure 1. Chart outlining the responsibilities in the test team

Table 2. Task responsibilities and contact information

Organization	Name	Responsibility	Contact information
KOMERI	Young-Soo Kim	Project Director	82-51-400-5143 catenatum@komeri.re.kr
	Jae-Uk Kang	Quality Assurance Manager	82-51-400-5170 jukang@komeri.re.kr
	Jun-Hyuk Yang	Field sampling manager Laboratory technician ≥ 50 μm organism	82-51-400-5145 jhyang@komeri.re.kr
	Hyung- Min Park	Archive personnel Laboratory technician ≥ 10 - 50 μm organism	82-51-400-5166 hmpark@komeri.re.kr
	Jun-Hak Lee	Statistical personnel Laboratory technician Bacteria	82-51-400-5149 jhlee@komeri.re.kr

Quality Assurance Project Plan (QAPP)

1. PROJECT AND TASK DESCRIPTION

1.1 Operation procedure of the AquaStar™ BWMS

The schematic diagram of the AquaStar™ BWMS is shown in Figure 2.

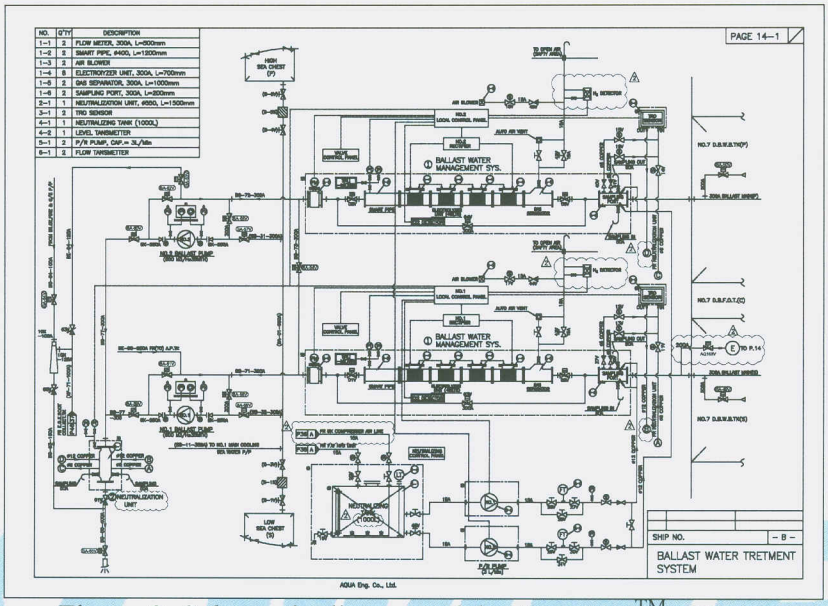

Figure 2. Schematic diagram of the AquaStar™ BWMS

The water flow diagrams during ballasting and de-ballasting operations are shown in Figure 3 and 4, respectively.

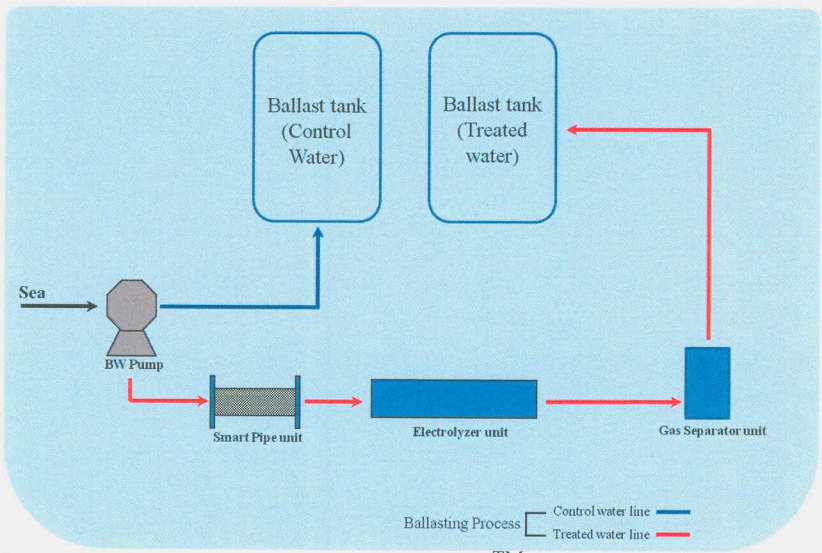

Figure 3. Flow diagram of the AquaStar™ BWMS during ballating

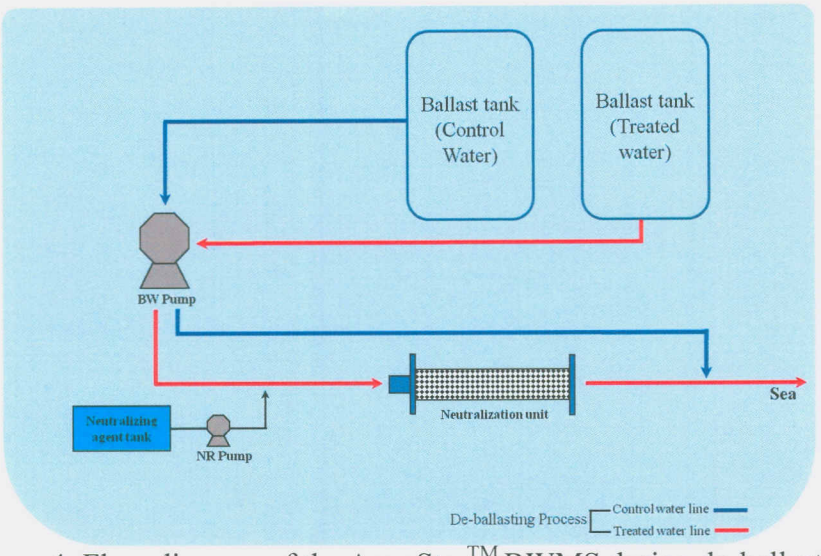

Figure 4. Flow diagram of the AquaStar^{TM} BWMS during de-ballasting

1.2 Task

The shipboard testing of the AquaStar^{TM} BWMS in accordance with the G8 is composed of the following tasks:

(1) Efficacy testing of the AquaStar^{TM} BWMS
(2) Reporting and evaluation of test results

1.3 Test schedule

Table 3. Test schedule

Test cycle	Year / Month / Day		Test site	
	Ballasting	de-Ballasting	Ballasting	de-Ballasting
1	2011/03/06	2011/03/14	Busan new port, Korea	Singapore port, Singapore
2	2011/08/21	2011/08/28	Singapore port, Singapore	Busan new port, Korea
3	2011/10/23	2011/10/28	Hongkong port, Hongkong	Tongyoung bay, Korea

2. MEASUREMENT AND DATA ACQUISITION

2.1 Test process design

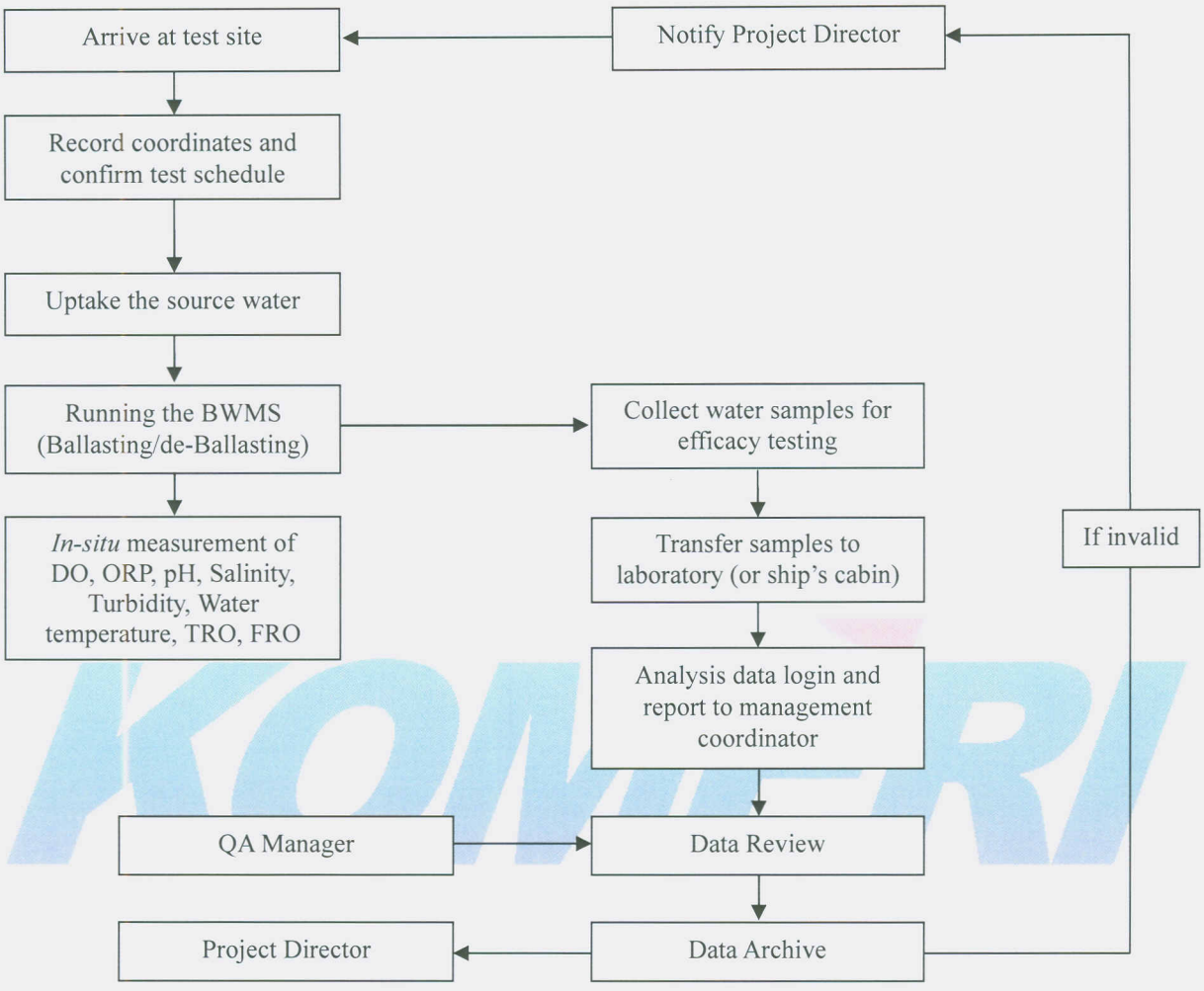

Figure 5. Test activities and data management process

2.2 Sampling

Sample collection plans will be applied during the sample collection periods. These plans will include detailed information on the sample locations, and the types of samples to be collected. The Project Director will apply the sample collection plan and brief the sample collection team on the objectives of the sampling.

2.2.1 Sampling information

Table 4. Sampling information

Sample	Volume (L)	Remark
Source water (ballasting)	25	Basic water parameter (DO, ORP, pH Salinity, Temperature, Turbidity, DOC/POC*, TSS) Viable organisms (≥ 50 μm, ≥ 10-50 μm) Bacteria (Heterotrophic, Total Coliform, *Escherichia coli*, Intestinal Enterococci, toxicogenic *Vibrio cholerae*)
Influent water (ballasting)	150	
Discharged control water (de-ballasting)	150	
Discharged treated water (de-ballasting)	10,000	

* POC is estimated value from difference between TOC and DOC.

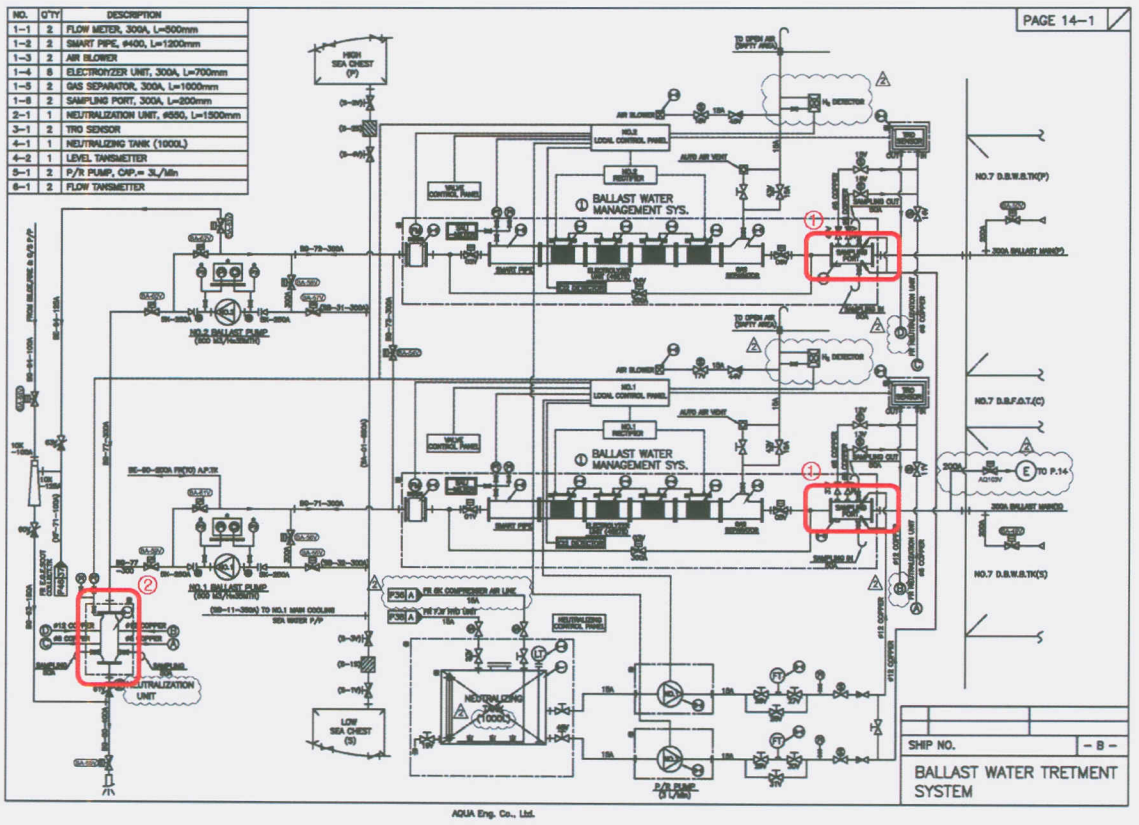

Figure 6. Sampling location (①: Control water ②: Treated water)

Table 5. Sample tag

Operation mode			Sample tag
Source water			-
Influent water		B	AS-C0B-1*
		M	AS-C0M-1
		E	AS-C0E-1
Discharge control water		B	AS-C5B-1
		M	AS-C5M-1
		E	AS-C5E-1
Discharge treated water	B	B	AS-T5B1-1
		M	AS-T5B2-1
		E	AS-T5B3-1
	M	B	AS-T5M1-1
		M	AS-T5M2-1
		E	AS-T5M3-1
	E	B	AS-T5E1-1
		M	AS-T5E2-1
		E	AS-T5E3-1

*AS: AquaStar™, C: control water, 0: during ballasting, B: Beginning, -1: 1st cycle.

2.2.2 Sampling methods

Sampling will be performed according to Water quality-Sampling-Part 3: Guidance on the preservation (ISO 5667-3, 2003), Standard Methods for the Examination of Water and Wastewater (APHA, 2005) and Coastal 2000 Northeast Component 'Field Operation Manual' (US EPA, 2000).

Sample should be collected in HDPE bottle or sterilized pack. All sampling bottle must be rigorously cleaned and rinsed with ultra-pure water. And then all bottles and packs will be attached identification tags.

- ***Viable organisms***

≥ 50 μm organisms will be collected using a plankton net of 45 μm diagonal mesh size immersed in a 1 m^3 of water tank. The plankton net will be rinsed with filtered ballast water. Organisms will be properly concentrated from 1 m^3 of treated water and 20 L of control water.

≥ 10 - 50 μm organisms will be collected using a plankton net of 7~8 μm diagonal mesh size of immersed in a 1 m^3 of water tank. The plankton net will be rinsed with filtered ballast water. Organisms will be properly concentrated from 1 L of treated water and 1 L of control water.

All samples will be placed in cooler boxes, which are electronically adjusted to the ambient water temperature for plankton, and then transferred to the ship's cabin or other place for analysis by car within 1 hour after sampling; sample analysis will be commenced within an hour of arrival at the ship's cabin or place for analysis.

- ***Bacteria***

1 or 2 L sterilized disposable polyethylene (PE) packs will be used for each sample collection. After sample collection, each sample bottle will be put into a 4 °C cooler box to ensure proper maintenance of storage temperature and care will be taken to prevent sample bottles from being totally immersed in water during transit. Sample analysis should begin immediately, preferably within 2 hours of collection. The maximum transport time to the place for analysis is 1 hour.

- ***DOC/POC***

Because of the possibility that oxidation or bacterial decomposition of dissolved components might occur in collected samples, the time between sample collection and the start of analysis should be minimized. Also, samples should be kept cool (4 °C) and protected from sunlight and atmospheric oxygen. In instances where analysis cannot be performed within 2 hours from sampling time, the sample will be acidified (pH < 2) with HCl or H_2SO_4 (7 days, ISO 5667-3).

2.2.3 Sample handling and custody

In order to minimize the possibility of contamination and introduction of artifacts, a procedure will be developed to collect, transport and preserve the samples for analysis. Special care will be taken to prevent the volatilization from filtered samples, to prevent adverse temperature-effect on water samples, as well as to prevent contamination of collected samples with ubiquitous gaseous air pollutants.

Specific procedures to ensure the integrity of the collected samples will be outlined in the SOPs developed for each instrument. However these should include the necessary procedures for ensuring sample validity by:

- Preparation of sampling material, including procedures to clean water samples, loading water samples into sampling apparatus, and transport of sampling media to field locations
- Storage of sampling media once removed from sampling location including sealing procedures and temperature requirements for transportation from field locations to place for analysis

- Archiving of sampling material until the analysis can be performed including prevention of photochemical and temperature changes
- Requirement for removing samples from archive for analysis that preserve sample integrity

Sample custody will be documented with sample log sheet for each water sample that will track the lifetime from preparation and cleaning, deployment to the place for analysis.

2.3 Analysis methods

Accuracy of analysis will be assessed for compliance with the criteria established in Korea Laboratory Accreditation Scheme (KOLAS) for efficacy testing. All testing and analysis will be carried out by scientific and technical staff who belongs to KOMERI.

Table 6. Laboratory analysis methods

Parameter	Method
Basic water parameter	
Salinity	APHA Standard Method[a] 2520 B
Dissolved oxygen	ASTM D888-09 Test Method C
Water temperature	APHA Standard Method 2550
pH	APHA Standard Method 4500-H^+ B
Oxidation-reduction potential	APHA Standard Method 2580
Total organic carbon	ISO 8245:1999
Dissolved organic carbon	ISO 8245:1999
Total suspended solid	APHA Standard Method 2540 D
Turbidity	APHA Standard Method 2130 B
Efficacy testing	
≥ 50 μm Organism	Fleming & Coughlan (1978)[b] US EPA 600/R-10/146 (2010)[c] APHA Standard Method 10200 C
≥ 10 - 50 μm Organism	Anja *et al.* (2005)[d] APHA Standard Method 10200 C Manual and Guide, UNESCO (2005) UNESCO 4 (2003) US EPA 445.0:1997
Heterotrophic bacteria	APHA Standard Method 9215
Coliform	APHA Standard Method 9222 B
Escherichia coli	US EPA 1603:2009
Intestinal Enterococci	US EPA 1600:2009
Toxicogenic *Vibrio cholerae* (O1, O139)	APHA Standard Method 9260 H
TOC (DOC/POC)	ISO 8245:1999

[a] Standard Methods. 2005. In: A.D Eaton, L.S Clesceri, E.W Rice, A.E Greenberg (eds), *Standard Methods for the Examination of Water and Wastewater*. Baltimore, Maryland. APHA, AWWA and WEF.

[b] Fleming, J.M., Coughlan, J. 1978. Preservation of vitally stained zooplankton for live/dead sorting. Estuaries (1) 135-137.

[c] US EPA 600/R-10/146. 2010. Protocol for the Verification of Ballast Water Treatment Technologies. Section 5.4.6.4. p45.

[d] Anja S, T. Cheryl, S. James, S. Kristin. 2005. Application of Alamar blue/5-carboxyfluorescein diacetate acetoxymethyl ester as a noninvasive cell viability assay in primary hepatocytes from rainbow trout. *Analytical Biochemistry*. (344) 76-85.

2.4 Data acquisition

2.4.1 Documentation and records

- **QAPP**

The Master Copy of the QAPP will be kept in electronic copy at a security data server at KOMERI.

The Quality Assurance Manager, Jae-Uk Kang, is the overall Quality Manager for this QAPP and has responsibility for controlling its currency and ensuring that all personnel listed in Approval Sheet have up-to-date, controlled copies of the document, sent by email as a Read Only (non-changeable) PDF file. Record of Distribution is to be kept as hard copy on file no. [Data file for BWMS Shipboard test AQUA AquaStar™] and saved in electronic copy at file directory [D:\BWMS\AQUA AquaStar™\Ship\KOMERI\QAPP].

The QA Manager will then ensure that the updated QAPP is distributed to all personnel listed in Approval Sheet, again by email as a Read Only (non-changeable) PDF file, and that the Record of Distribution is completed. Personnel are to be confirmed by email to the Project Director/QA Manager when they receive updated versions of the QAPP, which are to be filed as per paragraph. Such confirmation e-mails are to be printed and filed as hard copy on file no. [Data file for BWMS Shipboard test AQUA AquaStar™] and saved in electronic copy at file directory [D:\BWMS\AQUA AquaStar™\Ship\KOMERI\QAPP].

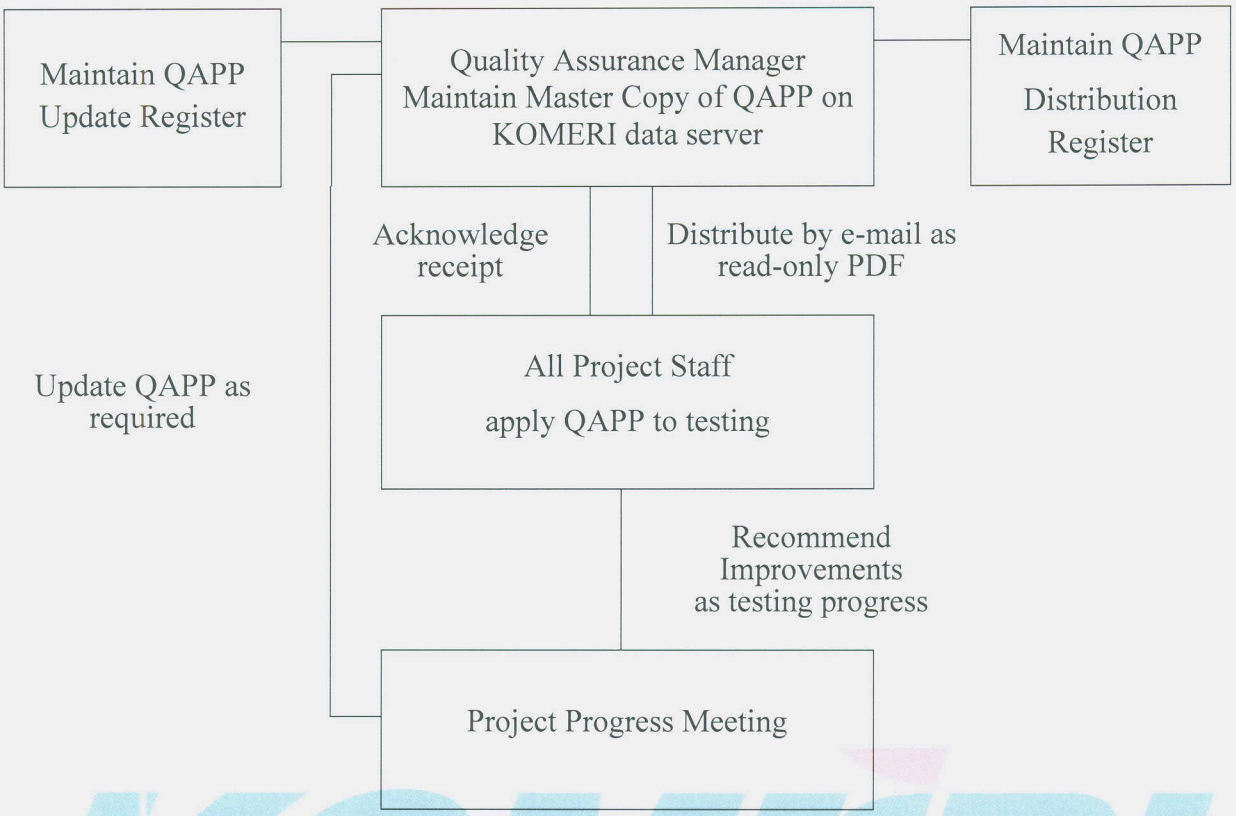

Figure 7. QAPP document control process

- **Field sample records**

Field sample records are to be accompanied by a Chain of Custody (COC) format at each sampling time, and then bound for keeping.

- **System monitor and operation records**

All operation data including water temperature, flow-rate and electric power consumption are to be accompanied by a Chain of Custody (COC) format at each test cycle, and then bound for keeping.

- **Chain of custody (COC) records**

The transport of all samples from field sampling to the laboratory for analysis is to be accompanied by a COC. The COC is to be completed at each step in the transport chain, with each party in the transport exchange keeping a copy of the Record; which is to be filed by each party for future reference if necessary.

- **Laboratory raw data records**

Analysis raw data log sheets are used for data recording and are to be accompanied by a COC format at each time of analysis, and then bound for keeping.

2.4.2 Data management

- **Data recording**

Data are transposed from field notebooks and analysis raw data log sheet to an electronic data-base.

- **Data validation**

Data are validated to ensure that the system performs the intended function consistently, reliable, and accurately in generating the data in accordance with KOLAS (ISO/IEC 17025).

- **Data transformation**

It is expected that data transformations made during this investigation will be relatively simplistic and all calculations made during data transformation will be checked 100% prior to dissemination of the transformed information.

- **Data transmittal**

During the transfer of data from one place (field notebook or data report) to another (electronic data spreadsheet) the data will be copied and checked by one individual and then checked 100% by a second individual to ensure accuracy.

- **Data reduction**

Raw data from field measurements are recorded directly in field notebooks or on sample log. If errors are made, results will be legibly crossed out, legibly signed and dated by the person recording the data, and corrected in a space adjacent to the original entry. Logbooks will be periodically reviewed by the Project Director and QA Manager to insure that records are complete, accurate, and legible. Reduction of current water quality test data will be made by entering all field collected data in an EXCEL® computer spreadsheet.

Laboratory data reduction procedures will be performed according to the following protocol. All information related to analysis will be documented in controlled laboratory logbooks, instrument printouts, or other approved forms. All entries that are not generated by an automated data system will be made neatly and legibly in waterproof ink. Corrections will be made by drawing a single red line with personnel signature through the error and entering the

correct information adjacent to the cross out. All changes will be legibly signed, dated, and if appropriate, accompanied by a brief explanation. Analysis laboratory records will be reviewed by the Section Supervisors on a regular basis and by the laboratory QA/QC officer periodically, to verify adherences to documentation requirements.

- **Data analysis**

The data generated during initial test periods in this project will be used to calculate the efficiency of ballast water treatment system during the test periods. Treatment efficiency will be used to calculate charging/discharging to and from the ballast tank, and to verify the system durability and/or stability.

- **Data tracking**

Data will be recorded in the field notebooks and upon return completion of the associated data collection information will be transposed to an electronic spreadsheet or Acrobat Reader (PDF) format. Copies of field data will be made and stored in project file on a daily basis. Laboratory data will also be transposed to an electronic spreadsheet format upon receipt.

- **Data storage and retrieval**

Data will be maintained in electronic format using MS EXCEL for data analysis and presentation purposes. Backup copies of all data files will be made intermittently throughout the project and upon completion of the project, a DVD containing all electronic data will be produced with copies available for distribution.

- **Data release**

Prior to being released as final, laboratory data will proceed through a tiered review process. Each analyst will be responsible for reviewing the analysis and QC data that he/she has generated. As part of this review, the analyst will verify that:

- The appropriate methodology was used,
- Instrumentation was functioning properly,
- QC analysis were performed at the proper frequency and the analysis met the acceptance criteria,
- Samples were analyzed within due time,
- All data were generated within the calibration range,
- Matrix interference problems were confirmed,
- Method-specific analysis requirements were met, and
- Calculations, dilution factors, and detection limits were verified.

Prior to releasing the final data, the section supervisor will review the data to:

- Verify the appropriate methodology was used,
- Verify QC analysis were performed at the proper frequency and the analysis met the acceptance criteria,
- Verify samples were analyzed within due time,
- Review and document problems encountered during the analysis.

The final data report will be reviewed and approved by Project Director and QA Manager prior to its release.

2.4.3 Data validation and usability

(1) Data review

Once these goals and objectives are evaluated and approved the AquaStar^{TM} BWMS, analysis data quality will be assessed to determine if the objectives have been met. In addition, the data will be reviewed by KOMERI's QA Manager for indications of interference of results by sample matrices, cross contamination during sampling, cross contamination in the laboratory, and sample preservation and storage anomalies.

(2) Validation and verification methods

- ***Efficacy testing***

The procedures used to evaluate field and laboratory analysis data will include checking procedures used in the field, ensuring that field measurement equipment was properly calibrated, checking for transcription errors, and comparing the data to historic data or verifying its 'reasonableness'. Evaluation of field data will be the responsibility of the Project Director or his designee.

An independent assessment of the data will be performed by KOMERI. The overall completeness of the data package will be evaluated. Completeness checks will be administrated on all data to determine whether the deliverables in accordance with the requirements specified in the QAPP are present.

Accuracy of laboratory analysis will be assessed for compliance with the criteria established in section Calibration and Quality Control Check of the Final Report using the analysis results of method blanks and DOC/POC samples. The percent recovery (%R) for DOC/POC samples will be determined according to the following equation:

$$\%R = [(Amount\ in\ spiked\ sample \times Amount\ in\ sample) / Known\ amount\ added] \times 100$$

%R for DOC/POC will be determined according to the following equation:

$$\%R = (Experimental\ concentration / Known\ amount\ added)\ X\ 100$$

For unknown viable organisms (≥ 50 and ≥ 10 - 50 μm), if cannot be identified in the samples should be sent to an appropriate agency for identification by an expert taxonomist where possible. It might be noted here that smaller phytoplankton are poorly known taxonomically and it may not be possible to identify these. Data from expert taxonomists are compared with archived KOMERI data for confirmation.

Precision of quantitative methods (APHA Standard Methods 9020B) will be used for data assessment of heterotrophic bacteria.

- Perform duplicate analysis on the first 2 positive samples of each type, with each set of duplicates analyzed by a single analyst. Duplicate analysis are recorded as D_1 and D_2.
- Calculate the logarithm of each result. If either of a set of duplicate results is <1, add 1 to both values before calculating the logarithms.
- Calculate the range (R) for each pair of transformed duplicates as the mean ($\overline{R}$) of these ranges.

Thereafter, analyze more than 10 % of routine samples in duplicate.

3. QUALITY ASSURANCE SYSTEM

3.1 Quality assurance objectives

Quality assurance objectives for KOMERI are listed in Table 7. Individual research/study/test projects may develop QA objectives that will replace the objectives listed in the Table 8.

Table 7. Quality assurance objectives of KOMERI

Analysis item	Unit	Method detection limit	Concentration range	Precision objective	Accuracy objective
Water Temperature	°C	NA	-5 ~ 50	0.01	± 0.1
Salinity	PSU	1.0	≤ 100	1%	± 1.0
pH	pH unit	0.0	0 ~ 14	± 0.01	± 0.2
Dissolved oxygen	mg/L	0.1 0.2	< 8 mg/L > 8 mg/L	0.01	± 0.1 ± 0.2
ORP	mV	1.0	-999 ~ 999	1.0	± 20
Turbidity	NTU	0.1	0 ~ 100 NTU 100 ~ 400 NTU 400 ~ 3000 NTU	0.1 - 1.0	1% 3% 5%
Total suspended solid	mg/L	0.1	NA	5%	± 0.10
Organisms, ≥ 50 µm	inds./m^3	1	NA	≤ CV 15%	≥ 95 %[b]
Organisms, ≥10 - 50 µm	inds./mL	1	NA	≥ 75 % average PSC	≥ 95 %[b]
Heterotrophic bacteria	cell/mL	1	30 ~ 300	≤ CV 5%	≥ 95 %[b]
Coliform	CFU/100 mL	1	20 ~ 80	≤ CV 5%	≥ 95 %[b]
Escherichia coli	CFU/100 mL	1	20 ~ 80	≤ CV 5%	≥ 95 %[b]
Intestinal Enterococci	CFU/100 mL	1	20 ~ 60	≤ CV 5%	≥ 95 %[b]
Toxicogenic *Vibrio cholerae* (serotype O1 and O139)	CFU/100 mL	1	NA	≤ CV 5%	≥ 95 %[b]

[a] Quality Control of TOC maintained by inter-laboratory comparison test.
[b] In general, accuracy should be within the range of 70 – 130 percent recovery of exogenous analyte.

Water quality meters (multi-probe) will be daily pre-calibrated prior to the commencement of field activities in accordance with manufacturer's instruction. Suspect calibration information will be highlighted in the field data notebook upon discovery of the information. Data collected during the period of suspect information will be footnoted as being questionable.

Table 8. Quality assurance sample types, frequency of use, and types of data generated for KOMERI

Parameters	QA sample type or measurement procedure	Frequency of use	Data generated for calibration and redundancy
Chemical water quality MS5 sonde (Hydrolab)			
Salinity	Certified standard conductivity solution (~ 50 µS/cm)	Each test cycle	Difference between probe value and standard level
Dissolved oxygen	Water-saturated air calibration	Each test cycle	Difference between probe value and saturation level
Water Temperature	QC check with standard	Each test cycle	Difference between probe

	thermometer		and thermometer
pH	QC check with standard buffers	Each test cycle	Difference between probe and standards
Dissolved organic carbon	QC check with standard (potassium hydrogen phthalate) / Proficiency testing	Each test cycle	Difference between sample and duplicate
Total organic carbon	QC check with standard (potassium hydrogen phthalate) / Proficiency testing	Each test cycle	Difference between sample and duplicate
Total suspended solid	QC check with duplicate	Each test period	Difference between sample and duplicate
Chemical water quality Turbidity meter (HACH)			
Turbidity	Certified standard turbidity solution (0, 10, 100, 1000 NTU)	Each test period	Difference between sample and duplicate
Biological water quality			
Organisms ≥ 50 µm	QC check duplicate and other identification data	Each test period / species assemblage	Comparison of 5 samples, standard deviation
Organisms ≥ 10-50 µm	QC check duplicate and other identification data	Each test period / species assemblage	Comparison of 5 samples, standard deviation
Bacteriological water quality			
Heterotrophic bacteria	QC check duplicate	Each test period and/or every sample	Comparison of 5 samples, standard deviation
Coliform	QC check duplicate	Each test period and/or every sample	Comparison of 5 samples, standard deviation
Escherichia coli	QC check duplicate	Each test period and/or every sample	Comparison of 5 samples, standard deviation
Intestinal Enterococci	QC check duplicate	Each test period and/or every sample	Comparison of 5 samples, standard deviation
Toxicogenic *Vibrio Cholerae* (O1, O139)	QC check duplicate	Each test period and/or every sample	Comparison of 5 samples, standard deviation

3. 2 Quality control procedures

Three types of internal quality control samples, blank sample and/or duplicates sample are routinely used at the laboratory.

A field duplicate is a sample which is collected immediately after the regular sample at the same location. This type of co-located field duplicate is estimated precision of the whole sampling process including inherent variability at the field site.

The quality control samples used are:

- A synthetic water quality control check sample is analyzed at least twice in each run of pH, salinity, water temperature, oxidation-reduction potential, dissolved oxygen and turbidity samples.
- In case of plankton, two sets of the dyed and undyed samples are prepared.
- For the analysis of bacteria, the routine analysis of positive and negative controls, filter sterility checks, method blanks and media sterility checks are required.

4. ASSESSEMENT/OVERSIGHT

4.1 Assessments and corrective actions

The laboratory as part of their QA program will conduct laboratory performance and system audits. System audits will be done on an annual basis at a minimum and will include an examination of laboratory documentation on sample receipt/log-in/storage/chain-of-custody, procedures, sample preparation and analysis, instrument operating records, etc.

Field audits will include examination of field sampling records/screening results/instrument operating records, sample collection, handling, and packaging in compliance with the established procedures, maintenance of QA procedures, chain-of-custody, etc. Follow-up audits will be conducted to correct deficiencies, and to verify that QA procedures are maintained through the investigation. The audits will involve reviews of field measurement records, instrumentation calibration records, and sample documentation.

The corrective action is the process of identifying, recommending, approving, and implementing measures to counteract unacceptable procedures or out-of-limit QC performance that can affect data quality. Corrective actions can occur during field activities, laboratory analysis, data validation, and data assessment. Corrective actions should only be implemented after approval by the Project Director or his designee.

For non-compliance problems, a formal corrective action program will be determined and implemented at the time the problem is identified. The person who identifies the problem is responsible for notifying the Project Director.

4.2 Reports to management

The results of assessments conducted under this QAPP will be reported to the management after 1 period test Project Progress Meeting and remedial action in accordance with the procedures.

REFERENCES

Anja S, T. Cheryl, S. James, S. Kristin. 2005. Application of Alamar blue/5-carboxyfluorescein diacetate acetoxymethyl ester as a noninvasive cell viability assay in primary hepatocytes from rainbow trout. *Analytical Biochemistry*. (344) 76-85.

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장 비 중 간 점 검 기 록 서

Equipment check records

관리번호 Serial No.	KOMERI-10TA0027	장 비 명 Equipment name	탁도계 Portable Turbidimeter	설치장소 Installation Location	수중생물학시험실 Microbiology laboratory	
점검일자 Date	2011.03.04	점검주기 Inspection period	The day before test	관 리 자 Manager	정	김 영 수
					부	양 준 혁

작 성 Written by	확 인 Approved by
곽 형 신	김 영 수

점검요령 procedure	점검결과 Results
1. Formazin standard solution (<0.1, 20, 100, 800 NTU) 을 이용하여 Turbidimeter 센서를 보정한다. *1. Calibrate with a formazin standard solution (<0.1, 20, 100, 800 NTU).*	

Turbidity (NTU)							
< 0.1		20		100		800	
Before	After	Before	After	Before	After	Before	After
0.08	0.07	18	20	99	101	794	798

특기사항 Remarks	○ : 양호, △ : 수리 요망, X : 폐기

장 비 중 간 점 검 기 록 서

Equipment check records

관리번호 Serial No.	KOMERI-10TA0017	장 비 명 Equipment name	수질다항목측정기 Water Quality Multiprobes	설치장소 Installation Location	수중생물학시험실 Microbiology laboratory	
점검일자 Date	2011.03.04	점검주기 Inspection period	The day before test	관 리 자 Manager	정	김 영 수
					부	양 준 혁

작 성 Written by	확 인 Approved by
박 형 빈	김영수

점검요령 procedure

1. pH standard solution (pH 4, 7, 10) 을 이용하여 pH 센서를 보정한다.

1. Calibrate with a pH standard solution (pH 4, 7, 10).

2. ORP standard solution (228 mV) 을 이용하여 ORP 센서를 보정한다.

2. Calibrate with a ORP standard solution (228 mV).

3. Specific conductance standard solution (58.64 mS/cm) 을 이용하여 Conductivity 센서를 보정한 후, 초순수를 이용하여 Salinity 값이 0 psu를 읽는지 확인한다.

3. Calibrate with a specific conductance standard solution (58.64 mS/cm) and then confirm (0 psu) with Ultrapure water.

4. DO 센서의 보정은 대기압 (760 mmHg) 을 이용하여 보정한 후, Na_2So_3 포화수용액을 이용하여 DO (mg/L) 값이 0 mg/L 을 읽는지 확인한다.

4. Calibrate in the atmosphere (ambient condition), and then confirm (0 mg/L) with saturated Na_2So_3 solution.

점검결과 Results

pH					
4		7		10	
Before	After	Before	After	Before	After
3.98	4.00	6.94	7.00	9.81	10.0

OPR (mV)		Conductivity (mS/cm)		Salinity (psu)		DO (mg/L)	
Before	After	Before	After	Before	After	Before	After
227	228	58.61	58.64	0.06	0.00	0.04	0.00

특기사항 Remarks	○ : 양호, △ : 수리 요망, X : 폐기

장 비 중 간 점 검 기 록 서

Equipment check records

관리번호 Serial No.	KOMERI-10TA0027	장 비 명 Equipment name	탁도계 Portable Turbidimeter	설치장소 Installation Location	수중생물학시험실 Microbiology laboratory	
점검일자 Date	2011.03.11	점검주기 Inspection period	The day before test	관 리 자 Manager	정	김 영 수
					부	양 준 혁

작 성 Written by	확 인 Approved by
김 영 수	양 준 혁

점검요령 procedure	점검결과 Results

1. Formazin standard solution (<0.1, 20, 100, 800 NTU) 을 이용하여 Turbidimeter 센서를 보정한다.

1. Calibrate with a formazin standard solution (<0.1, 20, 100, 800 NTU).

Turbidity (NTU)							
< 0.1		20		100		800	
Before	After	Before	After	Before	After	Before	After
0.07	0.07	19	21	98	98	196	199

특기사항 Remarks	○ : 양호, △ : 수리 요망, X : 폐기

장 비 중 간 점 검 기 록 서

Equipment check records

관리번호 Serial No.	KOMERI-10TA0017	장 비 명 Equipment name	수질다항목측정기 Water Quality Multiprobes	설치장소 Installation Location	수중생물학시험실 Microbiology laboratory	
점검일자 Date	2011.03.11	점검주기 Inspection period	The day before test	관 리 자 Manager	정	김 영 수
					부	양 준 혁

작 성 Written by	확 인 Approved by
박 형 빈	김영수

점검요령 procedure

1. pH standard solution (pH 4, 7, 10) 을 이용하여 pH 센서를 보정한다.

1. Calibrate with a pH standard solution (pH 4, 7, 10).

2. ORP standard solution (228 mV) 을 이용하여 ORP 센서를 보정한다.

2. Calibrate with a ORP standard solution (228 mV).

3. Specific conductance standard solution (58.64 mS/cm) 을 이용하여 Conductivity 센서를 보정한 후, 초순수를 이용하여 Salinity 값이 0 psu를 읽는지 확인한다.

3. Calibrate with a specific conductance standard solution (58.64 mS/cm) and then confirm (0 psu) with Ultrapure water.

4. DO 센서의 보정은 대기압 (760 mmHg) 을 이용하여 보정한 후, Na_2So_3 포화수용액을 이용하여 DO (mg/L) 값이 0 mg/L 을 읽는지 확인한다.

4. Calibrate in the atmosphere (ambient condition), and then confirm (0 mg/L) with saturated Na_2So_3 solution.

점검결과 Results

pH					
4		7		10	
Before	After	Before	After	Before	After
3.92	4.00	6.98	7.00	9.91	10.0

OPR (mV)		Conductivity (mS/cm)		Salinity (psu)		DO (mg/L)	
Before	After	Before	After	Before	After	Before	After
227	228	58.64	58.64	0.01	0.00	0.04	0.00

특기사항 Remarks	○ : 양호, △ : 수리 요망, X : 폐기

장 비 중 간 점 검 기 록 서

Equipment check records

관리번호 Serial No.	KOMERI-10TA0028	장 비 명 Equipment name	탁도계 Portable Turbidimeter	설치장소 Installation Location	수중생물학시험실 Microbiology laboratory		작 성 Written by	확 인 Approved by
점검일자 Date	2011. 08. 19	점검주기 Inspection period	The day before test	관 리 자 Manager	정	김 영 수	박 형 빈	김 영 수
					부	양 준 혁		

점검요령 procedure	점검결과 Results
1. Formazin standard solution (<0.1, 20, 100, 800 NTU) 을 이용하여 Turbidimeter 센서를 보정한다. *1. Calibrate with a formazin standard solution (<0.1, 20, 100, 800 NTU).*	

Turbidity (NTU)							
< 0.1		20		100		800	
Before	After	Before	After	Before	After	Before	After
0.09	0.08	17	20	96	101	197	802

특기사항 Remarks	○ : 양호, △ : 수리 요망, X : 폐기

장 비 중 간 점 검 기 록 서

Equipment check records

관리번호 Serial No.	KOMERI-10TA0017	장 비 명 Equipment name	수질다항목측정기 Water Quality Multiprobes	설치장소 Installation Location	수중생물학시험실 Microbiology laboratory	
점검일자 Date	2011.08.19	점검주기 Inspection period	The day before test	관 리 자 Manager	정	김 영 수
					부	양 준 혁

작 성 Written by	확 인 Approved by
백 형 선	김 영 수

점검요령 procedure

1. pH standard solution (pH 4, 7, 10) 을 이용하여 pH 센서를 보정한다.

1. Calibrate with a pH standard solution (pH 4, 7, 10).

2. ORP standard solution (228 mV) 을 이용하여 ORP 센서를 보정한다.

2. Calibrate with a ORP standard solution (228 mV).

3. Specific conductance standard solution (58.64 mS/cm) 을 이용하여 Conductivity 센서를 보정한 후, 초순수를 이용하여 Salinity 값이 0 psu를 읽는지 확인한다.

3. Calibrate with a specific conductance standard solution (58.64 mS/cm) and then confirm (0 psu) with Ultrapure water.

4. DO 센서의 보정은 대기압 (760 mmHg) 을 이용하여 보정한 후, Na_2So_3 포화수용액을 이용하여 DO (mg/L) 값이 0 mg/L 을 읽는지 확인한다.

4. Calibrate in the atmosphere (ambient condition), and then confirm (0 mg/L) with saturated Na_2So_3 solution.

점검결과 Results

pH					
4		7		10	
Before	After	Before	After	Before	After
3.99	4.00	6.98	7.00	9.84	10.0

OPR (mV)		Conductivity (mS/cm)		Salinity (psu)		DO (mg/L)	
Before	After	Before	After	Before	After	Before	After
226	228	58.63	58.64	0.01	0.00	0.02	0.00

특기사항 Remarks	○ : 양호, △ : 수리 요망, X : 폐기

장 비 중 간 점 검 기 록 서

Equipment check records

관리번호 Serial No.	KOMERI-10TA0028	장 비 명 Equipment name	탁도계 Portable Turbidimeter	설치장소 Installation Location	수중생물학시험실 Microbiology laboratory	
점검일자 Date	2011.08.26	점검주기 Inspection period	The day before test	관 리 자 Manager	정	김 영 수
					부	양 준 혁

작 성 Written by	확 인 Approved by
강 형 신	김영수

점검요령 procedure	점검결과 Results
1. Formazin standard solution (<0.1, 20, 100, 800 NTU) 을 이용하여 Turbidimeter 센서를 보정한다. *1. Calibrate with a formazin standard solution (<0.1, 20, 100, 800 NTU).*	

Turbidity (NTU)

< 0.1		20		100		800	
Before	After	Before	After	Before	After	Before	After
0.07	0.08	20	21	98	100	800	198

특기사항 Remarks	○ : 양호, △ : 수리 요망, X : 폐기

장 비 증 간 점 검 기 록 서

Equipment check records

관리번호 Serial No.	KOMERI-10TA0017	장 비 명 Equipment name	수질다항목측정기 Water Quality Multiprobes	설치장소 Installation Location	수중생물학시험실 Microbiology laboratory	
점검일자 Date	2011.08.26	점검주기 Inspection period	The day before test	관 리 자 Manager	정	김 영 수
					부	양 준 혁

작 성 Written by	확 인 Approved by
박형빈	

점검요령 procedure

1. pH standard solution (pH 4, 7, 10) 을 이용하여 pH 센서를 보정한다.

1. Calibrate with a pH standard solution (pH 4, 7, 10).

2. ORP standard solution (228 mV) 을 이용하여 ORP 센서를 보정한다.

2. Calibrate with a ORP standard solution (228 mV).

3. Specific conductance standard solution (58.64 mS/cm) 을 이용하여 Conductivity 센서를 보정한 후, 초순수를 이용하여 Salinity 값이 0 psu를 읽는지 확인한다.

3. Calibrate with a specific conductance standard solution (58.64 mS/cm) and then confirm (0 psu) with Ultrapure water.

4. DO 센서의 보정은 대기압 (760 mmHg) 을 이용하여 보정한 후, Na_2So_3 포화수용액을 이용하여 DO (mg/L) 값이 0 mg/L 을 읽는지 확인한다.

4. Calibrate in the atmosphere (ambient condition), and then confirm (0 mg/L) with saturated Na_2So_3 solution.

점검결과 Results

pH					
4		7		10	
Before	After	Before	After	Before	After
3.97	4.00	7.00	7.00	10.0	10.0

OPR (mV)		Conductivity (mS/cm)		Salinity (psu)		DO (mg/L)	
Before	After	Before	After	Before	After	Before	After
227	228	56.66	58.64	0.10	0.00	0.01	0.00

특기사항 Remarks	○ : 양호, △ : 수리 요망, X : 폐기

장 비 중 간 점 검 기 록 서

Equipment check records

관리번호 Serial No.	KOMERI-10TA0028	장 비 명 Equipment name	탁도계 Portable Turbidimeter	설치장소 Installation Location	수중생물학시험실 Microbiology laboratory		작 성 Written by	확 인 Approved by
점검일자 Date	2011.10.21	점검주기 Inspection period	The day before test	관 리 자 Manager	정	김 영 수	곽 청 신	김 영 수
					부	양 준 혁		

점검요령 procedure	점검결과 Results
1. Formazin standard solution (<0.1, 20, 100, 800 NTU) 을 이용하여 Turbidimeter 센서를 보정한다. *1. Calibrate with a formazin standard solution (<0.1, 20, 100, 800 NTU).*	

Turbidity (NTU)							
< 0.1		20		100		800	
Before	After	Before	After	Before	After	Before	After
0.07	0.08	20	21	99	100	798	801

특기사항 Remarks	○ : 양호, △ : 수리 요망, X : 폐기

장 비 중 간 점 검 기 록 서

Equipment check records

관리번호 Serial No.	KOMERI-10TA0017	장 비 명 Equipment name	수질다항목측정기 Water Quality Multiprobes	설치장소 Installation Location	수중생물학시험실 Microbiology laboratory	
점검일자 Date	2011.10.21	점검주기 Inspection period	The day before test	관 리 자 Manager	정	김 영 수
					부	양 준 혁

작 성 Written by	확 인 Approved by
박 형 신	

점검요령 procedure

1. pH standard solution (pH 4, 7, 10) 을 이용하여 pH 센서를 보정한다.

1. Calibrate with a pH standard solution (pH 4, 7, 10).

2. ORP standard solution (228 mV) 을 이용하여 ORP 센서를 보정한다.

2. Calibrate with a ORP standard solution (228 mV).

3. Specific conductance standard solution (58.64 mS/cm) 을 이용하여 Conductivity 센서를 보정한 후, 초순수를 이용하여 Salinity 값이 0 psu를 읽는지 확인한다.

3. Calibrate with a specific conductance standard solution (58.64 mS/cm) and then confirm (0 psu) with Ultrapure water.

4. DO 센서의 보정은 대기압 (760 mmHg) 을 이용하여 보정한 후, Na_2So_3 포화수용액을 이용하여 DO (mg/L) 값이 0 mg/L 을 읽는지 확인한다.

4. Calibrate in the atmosphere (ambient condition), and then confirm (0 mg/L) with saturated Na_2So_3 solution.

점검결과 Results

pH					
4		7		10	
Before	After	Before	After	Before	After
4.00	4.00	6.63	7.00	9.99	10.0

OPR (mV)		Conductivity (mS/cm)		Salinity (psu)		DO (mg/L)	
Before	After	Before	After	Before	After	Before	After
228	228	58.61	58.64	0.04	0.00	0.02	0.00

특기사항 Remarks	○ : 양호, △ : 수리 요망, X : 폐기

장 비 중 간 점 검 기 록 서

Equipment check records

관리번호 Serial No.	KOMERI-10TA0028	장 비 명 Equipment name	탁도계 Portable Turbidimeter	설치장소 Installation Location	수중생물학시험실 Microbiology laboratory		작 성 Written by	확 인 Approved by
점검일자 Date	2011. 10. 27	점검주기 Inspection period	The day before test	관 리 자 Manager	정	김 영 수	박 형 빈	김영수
					부	양 준 혁		

점검요령 procedure	점검결과 Results
1. Formazin standard solution (<0.1, 20, 100, 800 NTU) 을 이용하여 Turbidimeter 센서를 보정한다. *1. Calibrate with a formazin standard solution (<0.1, 20, 100, 800 NTU).*	

Turbidity (NTU)							
< 0.1		20		100		800	
Before	After	Before	After	Before	After	Before	After
0.08	0.08	20	21	100	102	799	804

특기사항 Remarks	○ : 양호, △ : 수리 요망, X : 폐기

장 비 중 간 점 검 기 록 서

Equipment check records

관리번호 Serial No.	KOMERI-10TA0017	장 비 명 Equipment name	수질다항목측정기 Water Quality Multiprobes	설치장소 Installation Location	수중생물학시험실 Microbiology laboratory	
점검일자 Date	2011.10.27	점검주기 Inspection period	The day before test	관 리 자 Manager	정	김 영 수
					부	양 준 혁

작 성 Written by	확 인 Approved by
박 형 희	김영수

점검요령 procedure

1. pH standard solution (pH 4, 7, 10) 을 이용하여 pH 센서를 보정한다.

1. Calibrate with a pH standard solution (pH 4, 7, 10).

2. ORP standard solution (228 mV) 을 이용하여 ORP 센서를 보정한다.

2. Calibrate with a ORP standard solution (228 mV).

3. Specific conductance standard solution (58.64 mS/cm) 을 이용하여 Conductivity 센서를 보정한 후, 초순수를 이용하여 Salinity 값이 0 psu를 읽는지 확인한다.

3. Calibrate with a specific conductance standard solution (58.64 mS/cm) and then confirm (0 psu) with Ultrapure water.

4. DO 센서의 보정은 대기압 (760 mmHg) 을 이용하여 보정한 후, Na_2So_3 포화수용액을 이용하여 DO (mg/L) 값이 0 mg/L 을 읽는지 확인한다.

4. Calibrate in the atmosphere (ambient condition), and then confirm (0 mg/L) with saturated Na_2So_3 solution.

점검결과 Results

pH					
4		7		10	
Before	After	Before	After	Before	After
3.98	4.00	6.99	7.00	10.0	10.0

OPR (mV)		Conductivity (mS/cm)		Salinity (psu)		DO (mg/L)	
Before	After	Before	After	Before	After	Before	After
224	228	57.90	58.64	0.03	0.00	0.01	0.00

특기사항 Remarks	○ : 양호, △ : 수리 요망, X : 폐기